## *Observations of Occultations of Stars by the Moon, 1875, 6, 7 (with the deduced Equations between the Errors of the Lunar Elements); and of the Phenomena of Jupiter's Satellites, made at the Radcliffe Observatory, Oxford; continued from Vol. XXXV. No. 8, of the "Monthly Notices."*

(*Communicated by the Radcliffe Observer.*)

| No. | Day and Year of Observation. | Name of Object. | Phenomenon. | ☽'s Limb. | Oxford Mean Solar Time. h m s | Observer. |
|---|---|---|---|---|---|---|
| | 1875. | | | | | |
| 1 | Oct. 24 | $\sigma$ Leonis | Disapp. | Bright | 17 31 54·4 | F. B. |
| 2 | ,, | ,, | Reapp. | Dark | 18 20 32·3 | ,, |
| 3 | Nov. 8 | $\chi$ Aquarii | Disapp. | Dark | 9 20 45·4 | K. |
| 4 | Dec. 9 | 19 Arietis | Disapp. | Dark | 5 59 46·5 | K. & F. B. |
| | 1876. | | | | | |
| 5 | Jan. 3 | Lamont 23 | Disapp. | Bright | 7 38 32·7 | L. |
| 6 | ,, | ,, | Reapp. | Bright | 7 40 33·4 | ,, |
| 7 | Feb. 2 | 27 Arietis | Disapp. | Dark | 6 22 59·4 | K. & F. B. |
| 8 | ,, | ,, | Reapp. | Bright | 7 27 32·3 | F. B. |
| 9 | March 4 | B.A.C. 2097 | Disapp. | Dark | 10 54 58·4 | K. |
| 10 | April 1 | 47 Geminorum | Disapp. | Dark | 7 27 7·1 | L. & F. B. |
| 11 | ,, | W.B. (2) VII. 81, 2 | Disapp. | Dark | 7 41 37·7 | L. & F. B. |
| 12 | ,, 7 | B.A.C. 4225 | Disapp. | Dark | 8 22 52·9 | L. |
| 13 | ,, | *f* Virginis | Disapp. | Dark | 11 31 47·7 | L. & F. B. |
| 14 | July 13 | $\epsilon$ Piscium | Disapp. | Bright | 13 0 46·6 | F. B. |
| 15 | ,, | ,, | Reapp. | Dark | 13 54 28·9 | ,, |
| 16 | ,, 16 | 23 Tauri | Disapp. | Bright | 14 26 51·1 | ,, |
| 17 | ,, | 24 Tauri | ,, | ,, | 14 57 45·4 | ,, |
| 18 | ,, | $\eta$ Tauri | ,, | ,, | 14 59 17·3 | ,, |
| 19 | ,, | 23 Tauri | Reapp. | Dark | 15 21 17·1 | ,, |
| 20 | ,, | 27 Tauri | Disapp. | Bright | 15 33 14·9 | ,, |
| 21 | ,, | 26 Tauri | ,, | ,, | 15 35 1·8 | ,, |
| 22 | ,, | 28 Tauri | ,, | ,, | 15 35 44·7 | ,, |
| 23 | ,, | $\eta$ Tauri | Reapp. | Dark | 15 52 12·1 | ,, |
| 24 | Nov. 29 | 47 Arietis | Disapp. | Dark | 7 51 1·9 | L. & H. B. |
| | 1877. | | | | | |
| 25 | Jan. 30 | $\rho$ Leonis | Disapp. | Bright | 10 45 15·1 | L. |
| ,, | ,, | ,, | ,, | ,, | 10 45 15·8 | H. B. |
| 26 | ,, | ,, | Reapp. | Dark | 11 50 38 0 | L. |
| 27 | Feb. 26 | Regulus | Disapp. | Dark | 12 39 1·8 | L. |
| ,, | ,, | ,, | ,, | ,, | 12 39 0·4 | F. B. |
| 28 | ,, | ,, | Reapp. | Bright | 13 44 41·0 | L. |
| ,, | ,, | ,, | ,, | ,, | 13 44 40·9 | F. B. |

*Notes.*

No. 1. $\sigma$ *Leonis*, disapp. The star seemed to hang on the Moon's limb for 3 or 4 seconds, but ultimately disappeared instantaneously.

„ 2. „ reapp. The observation doubtful; I turned round to verify my counting, and, on again looking in the telescope, the star seemed to reappear at that moment.

„ 4. 19 *Arietis*, disapp. The time noted is that at which I last saw the star, which seemed to disappear behind a dense cloud. (K.)

„ 7. 27 *Arietis*, disapp. The disappearance was instantaneous and the observation good; the unilluminated disk of the Moon was distinctly visible. (K.)

„ 8. „ reapp. At the reappearance the star was faint; the time noted is thought to be certainly within $0^s.5$; the Moon's motion in N.P.D. was very rapid. (F.B.)

„ 10, 11. 47 *Geminorum*, disapp., and W.B. (2) VII. 81, 2, disapp. Instantaneous; the unilluminated disk of the Moon distinctly visible. (F.B.) The R.A. and N.P.D. of W.B. (2) VII. 81, 2 are obtained from three observations made in 1877.

„ 12. B.A.C. 4225, disapp. Doubtful to a second.

„ 13. *f Virginis*, disapp. The star very faint just previous to disappearance. (Both observers.)

„ 14. $\epsilon$ *Piscium*, disapp. The star appeared to hang for a few seconds on the Moon's limb, and then disappeared behind a projection.

„ 15. „ reapp. I am very doubtful about this time; probably too late.

„ 17. 24 *Tauri*, disapp. Faint at disappearance.

„ 18, 20. $\eta$ *Tauri*, disapp, and 27 *Tauri*, disapp. At both these phenomena the star hung on the Moon's limb for $2^s$, and overlapped it (the colour of the star being plainly distinguished from that of the Moon), and then disappeared instantaneously.

„ 21. 26 *Tauri*, disapp. Star very faint; observation doubtful.

„ 22. 28 *Tauri*, disapp. Disappearance instantaneous.

„ 23. $\eta$ *Tauri*, reapp. The reappearance had taken place at the time noted, when I just saw it at the edge of the field of the telescope.

„ 25. $\rho$ *Leonis*, disapp. and reapp. Unsteady; windy. (L.)

„ 27. *Regulus*, disapp. Disappearance instantaneous. (Both observers.)

In the following table of the errors of lunar elements resulting from the occultations, the Greenwich notation is used, and the elements of the *Nautical Almanac* are used uncorrected. All the computations have been made by Mr. Main by the method given in his treatise on *Spherical and Practical Astronomy*.

The observations are referred to by the Nos. of reference given above.

| No. | ″ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | + 11·30 | = + 0·6802 × $e$ | − 0·2425 × $f$ | − 0·6802 × $x$ | + 0·2427 × $y$ | − 0·2026 × $t$ | − 0·5396 × $m$ | − 0·9210 × $n$ |
| 2 | − 11·32 | = − 0·2003 × $e$ | − 0·9794 × $f$ | + 0·2003 × $x$ | + 0·9794 × $y$ | + 0·3038 × $t$ | + 2·6554 × $m$ | − 0·9207 × $n$ |
| 3 | + 3·15 | = + 0·8910 × $e$ | + 0·4384 × $f$ | − 0·8910 × $x$ | − 0·4388 × $y$ | − 0·1956 × $t$ | − 0·6335 × $m$ | − 0·9462 × $n$ |
| 4 | + 9·65 | = + 0·6204 × $e$ | − 0·7656 × $f$ | − 0·6204 × $x$ | + 0·7662 × $y$ | − 0·4953 × $t$ | + 0·7812 × $m$ | − 0·9885 × $n$ |
| 5 | − 5·95 | = − 0·5388 × $e$ | − 0·8423 × $f$ | + 0·5388 × $x$ | + 0·8423 × $y$ | − 0·0272 × $t$ | + 1·5823 × $m$ | − 0·9379 × $n$ |
| 6 | − 4·22 | = − 0·5856 × $e$ | − 0·8105 × $f$ | + 0·5856 × $x$ | + 0·8105 × $y$ | − 0·0026 × $t$ | + 1·4311 × $m$ | − 0·9379 × $n$ |
| 7 | + 3·20 | = + 0·9480 × $e$ | + 0·0988 × $f$ | − 0·9480 × $x$ | − 0·0974 × $y$ | − 0·3509 × $t$ | + 0·2551 × $m$ | − 0·9593 × $n$ |
| 8 | − 8·36 | = − 0·5222 × $e$ | + 0·8363 × $f$ | + 0·5222 × $x$ | − 0·8359 × $y$ | + 0·3814 × $t$ | − 2·2871 × $m$ | − 0·9597 × $n$ |
| 9 | + 7·72 | = + 0·5331 × $e$ | − 0·7937 × $f$ | − 0·5331 × $x$ | + 0·7945 × $y$ | − 0·2254 × $t$ | + 2·4694 × $m$ | − 0·9728 × $n$ |
| 10 | + 1·82 | = + 0·0979 × $e$ | + 0·9938 × $f$ | − 0·0979 × $x$ | − 0·9938 × $y$ | − 0·1504 × $t$ | − 1·4320 × $m$ | − 0·9689 × $n$ |
| 11 | + 10·64 | = + 0·7904 × $e$ | − 0·4482 × $f$ | − 0·7904 × $x$ | + 0·4502 × $y$ | − 0·3753 × $t$ | + 1·3358 × $m$ | − 0·9689 × $n$ |
| 12 | + 5·93 | = − 0·1375 × $e$ | + 0·9905 × $f$ | + 0·1375 × $x$ | − 0·9905 × $y$ | − 0·2164 × $t$ | − 2·5444 × $m$ | − 0·9305 × $n$ |
| 13 | + 9·02 | = + 0·6400 × $e$ | + 0·7668 × $f$ | − 0·6400 × $x$ | − 0·7670 × $y$ | − 0·4068 × $t$ | − 2·1331 × $m$ | − 0·9293 × $n$ |
| 14 | + 7·23 | = + 0·9904 × $e$ | + 0·0066 × $f$ | − 0·9904 × $x$ | − 0·0060 × $y$ | − 0·4202 × $t$ | − 1·9663 × $m$ | − 0·9342 × $n$ |
| 15 | (− 16·44) | = − 0·4036 × $e$ | + 0·9132 × $f$ | + 0·4036 × $x$ | − 0·9131 × $y$ | + 0·4040 × $t$ | − 1·5849 × $m$ | − 0·9347 × $n$ |
| 16 | (+ 28·23) | = + 0·7560 × $e$ | − 0·5592 × $f$ | − 0·7560 × $x$ | + 0·5606 × $y$ | − 0·5870 × $t$ | − 3·1938 × $m$ | − 0·9765 × $n$ |
| 19 | − 2·86 | = − 0·9002 × $e$ | + 0·1621 × $f$ | + 0·9002 × $x$ | − 0·1601 × $y$ | + 0·5468 × $t$ | + 1·6832 × $m$ | − 0·9770 × $n$ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17 | + 0·83 | = | + 0·5623 × $e$ | − 0·7866 × $f$ | − 0·5623 × $x$ | + 0·7874 × $y$ | − 0·5064 × $t$ | + 0·5069 × $m$ | − 0·9768 × $n$ |
| 18 | + 7·24 | = | + 0·6224 × $e$ | − 0·7301 × $f$ | − 0·6224 × $x$ | + 0·7311 × $y$ | − 0·5282 × $t$ | + 0·2325 × $m$ | − 0·9768 × $n$ |
| 23 | − 0·49 | = | − 0·9113 × $e$ | − 0·0108 × $f$ | + 0·9113 × $x$ | + 0·0130 × $y$ | + 0·4977 × $t$ | + 1·9306 × $m$ | − 0·9773 × $n$ |
| 20 | − 2·72 | = | + 0·8974 × $e$ | − 0·1743 × $f$ | − 0·8974 × $x$ | + 0·1763 × $y$ | − 0·5425 × $t$ | − 1·6254 × $m$ | − 0·9771 × $n$ |
| 21 | − 2·35 | = | + 0·6934 × $e$ | + 0·6430 × $f$ | − 0·6934 × $x$ | − 0·6418 × $y$ | − 0·2498 × $t$ | − 2·9640 × $m$ | − 0·9771 × $n$ |
| 22 | + 3·96 | = | + 0·8468 × $e$ | − 0·3687 × $f$ | − 0·8468 × $x$ | + 0·3705 × $y$ | − 0·5563 × $t$ | − 1·0790 × $m$ | − 0·9771 × $n$ |
| 24 | + 9·40 | = | + 0·9332 × $e$ | + 0·0671 × $f$ | − 0·9332 × $x$ | − 0·0653 × $y$ | − 0·4115 × $t$ | − 1·4271 × $m$ | − 0·9709 × $n$ |
| 25 | + 10·04 | = | + 0·9085 × $e$ | + 0·3815 × $f$ | − 0·9085 × $x$ | − 0·3807 × $y$ | − 0·5078 × $t$ | − 2·4465 × $m$ | − 0·9872 × $n$ |
| 26 | − 9·99 | = | − 0·7485 × $e$ | − 0·6480 × $f$ | + 0·7485 × $x$ | + 0·6486 × $y$ | + 0·4860 × $t$ | + 2·4259 × $m$ | − 0·9868 × $n$ |
| 27 | + 12·98 | = | + 0·8393 × $e$ | + 0·5066 × $f$ | − 0·8393 × $x$ | − 0·5058 × $y$ | − 0·4928 × $t$ | − 0·6266 × $m$ | − 0·9988 × $n$ |
| 28 | − 10·29 | = | − 0·7653 × $e$ | − 0·6180 × $f$ | + 0·7653 × $x$ | + 0·6188 × $y$ | + 0·5145 × $t$ | + 0·5042 × $m$ | − 0·9987 × $n$ |

## *Phenomena of Jupiter's Satellites.*

| No. | Day and Year of Obs. | Satellite. | Phenomenon. | Phase of Phenomenon. | Instrument. | Oxford Mean Solar Time of Observation. h m s | Greenwich Mean Solar Time from *N.A.* h m s | Observer |
|---|---|---|---|---|---|---|---|---|
| | 1875. | | | | | | | |
| 1 | June 28 | I | Occ. disapp. | First contact | 10-foot | 10 21 36·3 | | K. |
| | ,, | ,, | ,, | Bisection | ,, | 10 23 6·1 | 10 31 | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 10 27 5·4 | | ,, |
| 2 | ,, | II | Occ. disapp. | Bisection | ,, | 11 0 0·1 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 11 2 29·7 | 11 7 | ,, |
| | 1876. | | | | | | | |
| 3 | May 8 | I | Ecl. disapp. | Last seen | ,, | 12 17 8·1 | 12 21 55·9 | L. |
| 4 | ,, 9 | I | Shad. egr. | Last seen | ,, | 11 32 21·7 | 11 40 | ,, |
| 5 | ,, | I | Tr. egr. | First cont. | ,, | 11 41 20·2 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 11 46 59·4 | 11 51 | ,, |
| 6 | ,, 13 | II | Ecl. disapp. | Last seen | Heliom. | 9 30 33·8 | 9 35 36·2 | F. B. |
| 7 | ,, | II | Occ. reapp. | First seen | 10-foot | 12 9 23·9 | | L. |
| | ,, | ,, | ,, | Last cont. | ,, | 12 14 23·1 | | ,, |
| | ,, | ,, | ,, | First seen | Heliom. | 12 8 48·0 | 12 17 | F. B. |
| | ,, | ,, | ,, | Last cont. | ,, | 12 13 27·2 | | ,, |
| 8 | ,, 16 | I | Trs. ingr. | First cont. | 10-foot | 11 12 39·5 | | L. |
| | ,, | ,, | ,, | Last cont. | ,, | 11 17 8·7 | 11 23 | ,, |
| 9 | ,, 20 | II | Occ. disapp. | First cont. | ,, | 11 53 29·3 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 11 58 28·5 | | ,, |
| | ,, | ,, | ,, | First cont. | Heliom. | 11 52 44·1 | 12 1 | F. B. |
| | ,, | ,, | ,, | Bisection | ,, | 11 56 13·5 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 11 59 13·0 | | ,, |
| 10 | ,, 21 | III | Trs. ingr. | First cont. | 10-foot | 12 45 32·7 | | L. |
| | ,, | ,, | ,, | Last cont. | ,, | 12 58 50·5 | 13 2 | ,, |
| 11 | ,, 29 | II | Trs. egr. | First cont. | ,, | 11 39 47·0 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 11 49 15·4 | | ,, |
| | ,, | ,, | ,, | First cont. | Heliom. | 11 40 26·4 | 11 49 | F. B. |
| | ,, | ,, | ,, | Bisection | ,, | 11 43 16·0 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 11 46 0·6 | | ,, |
| 12 | ,, | II | Shad. egr. | First cont. | 10-foot | 12 12 11·7 | | L. |
| | ,, | ,, | ,, | Last cont. | ,, | 12 16 41·0 | 12 26 | ,, |
| 13 | ,, 31 | I | Occ. disapp. | First cont. | ,, | 12 3 12·2 | | L. |
| | ,, | ,, | ,, | Bisection | ,, | 12 4 41·9 | | ,, |
| | ,, | ,, | ,, | Last cont. | ,, | 12 6 41·6 | 12 11 | ,, |
| | ,, | ,, | ,, | First cont. | Heliom. | 12 1 20·5 | | F. B. |
| | ,, | ,, | ,, | Last cont. | ,, | 12 7 24·5 | | ,, |

| No. | Day and Year of Obs. | | Satellite. | Phenomenon. | Phase of Phenomenon. | Instrument. | Oxford Mean Solar Time of Observation. h m s | Greenwich Mean Solar Time from *N.A.* h m s | Observer. |
|---|---|---|---|---|---|---|---|---|---|
| 14 | June | 1875. 1 | III | Ecl. reapp. | ... | Heiom. | 9 10 1·4 | 9 16 24·5 | F. B. |
| 15 | ,, | | I | Trs. ingr. | First cont. | ,, | 9 10 52·3 | | ,, |
| | ,, | | ,, | ,, | Bisection | ,, | 9 12 7·1 | 9 18 | ,, |
| | ,, | | ,, | ,, | Last cont. | ,, | 9 14 21·8 | | ,, |
| | ,, | | ,, | ,, | Last cont. | 10-foot | 9 16 9·6 | | L. |
| 16 | ,, | | I | Shad. ingr. | Last cont. | ,, | 9 39 15·8 | | ,, |
| | ,, | | ,, | ,, | Bisection | Heliom. | 9 36 32·4 | 9 39 | F. B. |
| | ,, | | ,, | ,, | Last cont. | ,, | 9 38 17·2 | | ,, |
| 17 | ,, | | I | Trs. egr. | First cont. | 10-foot | 11 17 40·8 | | L. |
| | ,, | | ,, | ,, | Last cont. | ,, | 11 23 49·8 | | ,, |
| | ,, | | ,, | ,, | First cont. | Heliom. | 11 21 45·1 | 11 29 | F B. |
| | ,, | | ,, | ,, | Last cont. | ,, | 11 24 59·6 | | ,, |
| 18 | ,, | | I | Shad. egr. | First cont. | ,, | 11 37 53·5 | 11 51 | ,, |
| | ,, | | ,, | ,, | Last cont. | 10-foot | 11 41 27·0 | | L. |
| 19 | ,, | 14 | II | Ecl. reapp. | First seen | ,, | 11 41 22·1 | | ,, |
| | ,, | | ,, | ,, | Fully seen | ,, | 11 41 56·5 | 11 48 27·6 | ,, |
| | ,, | | ,, | ,, | First seen | Heliom. | 11 41 18·1 | | F. B. |
| 20 | July | 3 | III | Trs. egr. | Bisection | 10-foot | 10 57 57·4 | | L. |
| | ,, | | ,, | ,, | Last cont. | ,, | 11 7 55·8 | | ,, |
| | ,, | | ,, | ,, | First cont. | Heliom. | 10 51 16·5 | 11 10 | F. B. |
| | ,, | | ,, | ,, | Bisection | ,, | 10 57 30·6 | | ,, |
| | ,, | | ,, | ,, | Last cont. | ,, | 11 2 59·7 | | ,, |
| 21 | ,, | 14 | III | Ecl. reapp. | First seen | 10-foot | 9 3 36·9 | 9 12 8·0 | L. |
| | ,, | | ,, | ,, | Fully seen | ,, | 9 4 11·8 | | ,, |
| 22 | Aug. | 1 | II | Trs. egr. | First cont. | ,, | 9 0 22·2 | 9 5 | ,, |
| | ,, | | ,, | ,, | Last cont. | ,, | 9 6 1·3 | | ,, |
| 23 | ,, | | I | Occ. disapp. | First cont. | ,, | 9 50 45·7 | 9 57 | ,, |
| | ,, | | ,, | ,, | Last cont. | ,, | 9 53 35·2 | | ,, |
| 24 | ,, | 8 | II | Trs. ingr. | First cont. | ,, | 8 58 25·8 | 9 1 | ,, |
| | ,, | | ,, | ,, | Last cont. | ,, | 9 0 30·5 | | ,, |
| 25 | ,, | 9 | I | Trs. ingr. | First cont. | Heliom. | 8 54 51·0 | 9 3 | F. B. |
| | ,, | | ,, | ,, | Last cont. | ,, | 8 59 20·3 | | ,, |
| 26 | ,, | 10 | II | Ecl. reapp. | First seen | ,, | 8 39 50·9 | 8 46 59·5 | ,, |

*Notes.*

No.

1 Cloudy.

2 The satellite very faint; cloudy.

3 The satellite was at least $20^s$ passing into the shadow, which was almost coincident with the limb of the planet.

4 The shadow was very faint, only seen at intervals, but the time noted is supposed to be very near the last contact; windy during the observation.

6 The satellite had been fading in brightness and was almost in contact with the planet when I last saw it.

8 Unsteady; at the last contact the satellite seemed to be on the planet and to jump off again.

10 The satellite at last contact moved along the limb of the planet for more than half an hour, the two limbs being in contact at $13^h\ 21^m$; I did not think to look for the shadow till that time, when I was surprised to find it fully on the disk of the planet, with the limb just in contact. I thought every minute the satellite was coming off the planet, but on referring to the *Nautical Almanac* I found it would not do so for nearly two hours. Too tired to wait for the egress.

11 Uncertain. (L.)
The image of the planet very diffused. (F.B.)

12 Very doubtful. (L.)

13 Definition very bad. (L.)

14 Reappearance instantaneous.

16 Shadow very faint; probably the time noted is one minute too late. (L.)
The last contact is considered satisfactory. The times noted have been each diminished by five minutes. (F.B.)

17 The planet ill-defined; the satellite very faint. (Both observers.)

19 Very faint at reappearance. (L.)
Reappearance instantaneous, but the satellite faint owing to cloud. (F.B.)

20 Very unsteady and ill-defined; the satellite hung on the limb for some minutes after the last contact appeared to have taken place. (L.)
The planet was very tremulous, and the satellite seemed to hang on the limb for some minutes after last contact; at $11^h\ 12^m$ the satellite was quite detached from the limb. (F.B.)

22 The satellite faint.

24 Unsteady.

25 Cloudy during the observation; the planet was very badly defined and unsteady; the satellite seemed to jump away from it after the contact had taken place.

26 Cloudy during the observation; the satellite was very faint at the time of reappearance, and did not attain its usual brightness till one minute after.

The initials L., K., F.B., H.B. are those of Mr. Lucas, Mr. Keating, Mr. F. Bellamy, and Mr. H. Bellamy.

The instruments used were the heliometer with power of 200, and the 10-foot telescope with power of 160.

*April* 3, 1877.